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ABSTRACT

Most roofs are meant to withstand the elements for a period of 20 years; to achieve this goal, however, school officials must believe in a dedicated maintenance program and sell it to their superiors and school boards. Establishment of a school district roof maintenance program is explained. Job qualifications and training methods for an inhouse technician are outlined. The next steps involve mapping the roof and developing an inspection report--an ongoing task that must be done at least once, preferably twice, a year. An important part of a roof maintenance program is a historical record that points out specifications that worked or didn't work. The history sheet should include names of the architect, the general contractor, and the roofing contractor; completion date of the construction; and where the original plans and specifications are located. Three different nondestructive types of moisture detection scans--infrared, nuclear, and capacitant--are described. A table illustrates comparison of these scans for conventional build-up roof systems and single-ply systems. A summary of roof problems categorized as environmental stresses and physical plant stresses is followed by solutions to roofing problems. Different types of roof membranes and construction materials are defined and their advantages and disadvantages discussed. The final item in the paper is a 10-point checklist for writing roofing specifications. (MLF)

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October 15, 1984

ROOFS-THEIR PROBLEMS AND SOLUTIONS

ASBO's 1984 ANNUAL MEETING - October 14-18

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October 15, 1984 Carl J. Swentkofske

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I want to welcome you to the discussion on Roofs-Their Problems and Solutions and want to state that I am not Dr. Cure-all, never intended to be. I may bore some of you on some of the material used but it is needed to lead into what our solutions may be by getting background and history.

Most of our roofs, whether they are dead-level, minimal sloped, a good slope, are meant to withstand the elements for a period of twenty years. Now all of us know that if we get twenty years out of any roof system we are really ahead of the game. If we start with a new roof and maintain them the way they were meant to be maintained, we will get that twenty years. You have to spend money on a dedicated maintenance program. You must believe in it, sell it to your superiors and members of the Board that have to allocate funds for this type of maintenance.

One of the biggest things, if we look at our maintenance dollar when we go about maintaining our facilities would be the roofs. Some of us are fortunate enough to have a plumber, an HVAC person and an electrician on board. They are to take care of other maintenance problems that, if we look at our budget dollar, probably make up one-third of it. Where does the other two thirds go? Into roof maintenance, some preventative, other replacement. We are out doing whatever we have to do to get that umbrella over our heads to keep the water out.

Now, why don't I have a roof technician on my staff? We may have all asked ourselves that same question. We have had one for about two or three years. When I came into the Elmbrook District, this was one of my major goals to accomplish in a short period of time. Now, you may say, is it cost effective to have your own inhouse technician or should you go outside and hire one. Your own inhouse tech is readily accessible when emergencies come up. He is quite familiar with the roofs in the District in that he has surveyed them, mapped them, and many other

things. With a consultant you have to call him, his time has to be made available to you, he may not be in or he may be tied up for a week etc., many items will come up pros and cons. Once again, the big reasons for having your own technician is that he is readily available. He is really more familiar also with the conditions in your area, where a consultant is somebody fifty miles away. Can the so-called expert analyze your roofs and tell you what you should do with them?

Some background and thoughts on what to consider before you move into a program. We are a mix from all over the North American Continent, which has weather conditions that spread from the hot tropics to the frigid temperatures of the far north. What does this do to the membranes that we stretch across the expanses that are suppose to be roofs? The shock that takes place within the confines of the roof is tremendous. We can quote from one of the articles that I have given you, that says, "They are the coldest, they are the hottest, they are the windiest, the wettest, there is more dust, acid-rain pools, bird manure, and other chemicals that settle on that surface, and we expect it to keep us watertight without doing anything." In our District, we have about a million-and-a-half square feet under roof, and we spend annually in repairs, replacements, resaturation etc. somewhere between a quarter and a half million dollars per year. Now that is a big buck investment. What are we going to do to cut that down as the cost becomes higher and higher? I feel that the best way to maintain that investment is to be very knowledgeable about that investment and how we can keep it performing for us for the best return on our dollar.

I will try to outline our program, what we have done for the problems that come up and some of the solutions we hope will fit into your program somewhere down the line. The way I proceeded was first to set my goals and then determine how I would institute that program. I had made up my mind to hire a technician that would work directly under my supervision. When I established this, I had to say what qualifications do I want? Some of the things I looked for when I decided this was:

1. I don't necessarily want someone that has been in roofing for years.
   a. He probably knows how to put down a roof, what its made up of, but does he know all of the problems?
2. Someone that has knowledge of blueprints and how to read them, background in chemistry, metals, asphalts, and construction design.
3. Drafting is very helpful because when you start to establish history, he must be able to put it down in a picture form that a lot of people can understand.
4. Overall, he or she has to be a person that can retain knowledge, willing to roll up his/her sleeves and go to work, can stand his/her ground when following through on specifications with a contractor, make on-the-spot judgements if a contractor might suggest a change from specifications; these are some of the traits I feel must be looked at.

In my particular case, the person I chose did not have any roofing background other than what he picked up as a head custodian, but had a good head on his shoulders. We put him to work with roofing contractors that I had made prior arrangements with to work with their crews. We gathered up all the information from suppliers, their specs, different materials, different technics for putting materials down etc. We went out and purchased the NRCA Manual (National Roofing Contractors' Association Roofing and Waterproofing Manual). This is an invaluable guide for educating a tech, and also for specification writings, to be covered later. Along with Factory Mutual approved guides, loss prevention bulletins, there is a vast library out there that can be obtained at very little cost. Your supply house in your particular area that supplies the contractors with their material is a ready source of information along with contractors that you have worked with that can give you many hints that are good. Now you give the person time to sit down and read all the material to develop their knowledge.

Now that we have our technician trained, lets put him to work. The first thing

that you must develop is a map of your roof, which shows all of the protrusions, obstacles, whatever is on top of that plant. This is most important because in all schools we have added on and added on four or five different additions, parapet walls, expansion joints, everything. Your school probably started in a given year and then every few years you put on another addition; never the same type of a roofing system, never laid the same way, not the same insulation material so you have to know that particular plant roof. So develop a map showing the square footage of each piece between expansion joint walls etc. and mark those protrusions or obstacles a given way so that everytime it's the same. This can be done off of your prints, if they are available. If they are not available, then you have to do it by getting your man up there with the good old measuring wheel, tapes or whatever and develop that. If you develop it from the prints, then he should take that print to the building itself and make any notations of changes that might have happened, making sure that all of the joints are where they are suppose to be by the print or by visual inspection. This is very important. You also should note on your map the direction that the building sets, North, South, East, or West. They are important for when you start to record your problems, you may find that you have a particular problem that leaks when there is a West wind or any direction. You get up there and you find out that it is not a roof problem; there is a vent there and when the west wind is blowing, there is no way that you are going to keep the water out so you may have to develop something. These are things that are important. It also is important to develop the map of what is under the roof by the floor plan used for the curriculum, rooms, corridors, where the mechanical equipment rooms are, where the washrooms are, etc. If you have an overlay and the building engineer calls and says I have a leak in the art room, your technician knows where to go; he can orient himself in, he knows what problems are there by penetrations, and that type of thing.

The next thing is to develop an inspection sheet. That will show exactly what has

happened to that roof since the day it was laid, reroofed, planned or whatever. You must note on your inspection sheet to also look at the perimeter of the building. You can see the water spots or water leaks coming down the wall, where its been stained, stress cracks that are in the building that are naturally going to effect the roof. Then go inside and check ceilings. If you have a dropped ceiling, lift some tile so that you can visually look at the underside of the deck. This is very important, especially in a metal deck where you could have rusting or any type of degradation of the system. There are many forms available for your inspection. Each and every building probably would have a different type of problem but at least an overall commons so that anybody trying to develop the complete inspection system can look at the overall sheet and see the makeup of the decks, the years they were installed, whether there has been a roof over a roof, whether there has been a resat, and any number of different things. The inspection report has got to be very thorough and remember, one of the things when you are training your technician is that you want him to have an inquisitive mind--why is this a condition or why a west wind effects a building. When he is there inspecting, he looks at all of the open vents, what type of vents are there, can they be a problem without even penetrating the full membrane or the roof material (wall grills etc.) can be a problem. This is very important.

Your inspection report is an ongoing thing. Its not just when you start into a program. You must do that at least once a year, and it would be desirable to do it twice a year, especially in the changing climates where you have a hot season and a cold season. When you come out of the cold season, it should be inspected for the stress and thermo shock problems that may become apparent. When you go into the cold season would be the other time. You've gone through a hot season, dried them up, cracked them, a lot of traffic on it during the hot season can open things up. These are the times to do that inspection, and each time a thorough inspection. Dedication to your program.

The next very important part of your program is to develop your history, and you will find out that history helps you in many things. It can point out specifications that worked or didn't work depending on the type of roof or the type of deck. Metal decks will receive a certain type of roof, concrete another type. Is there a moisture problem from within? Is there a moisture barrier? You may think you have a leaky roof, and its actually the moisture from within that starts to turn around and come back out again. Moisture content is a very important fact, depending upon your history. Some things to have on your history sheet: Who was the architect? Who was the general contactor? Who was the roofing contractor? What was the completion date of the construction? Where are the original plans and specifications located? What was the design load of the roof structure? What was the specification of the original roof system? What is the specification of the current roof system? What type of roof deck was used? What kind of roof insulation was used and what is the thermal value? Is there a current guarantee on the roof system? What is the history of repairs and reroofing? What is the access to the roof? You will find out that history will tell you many things and make your job easier.

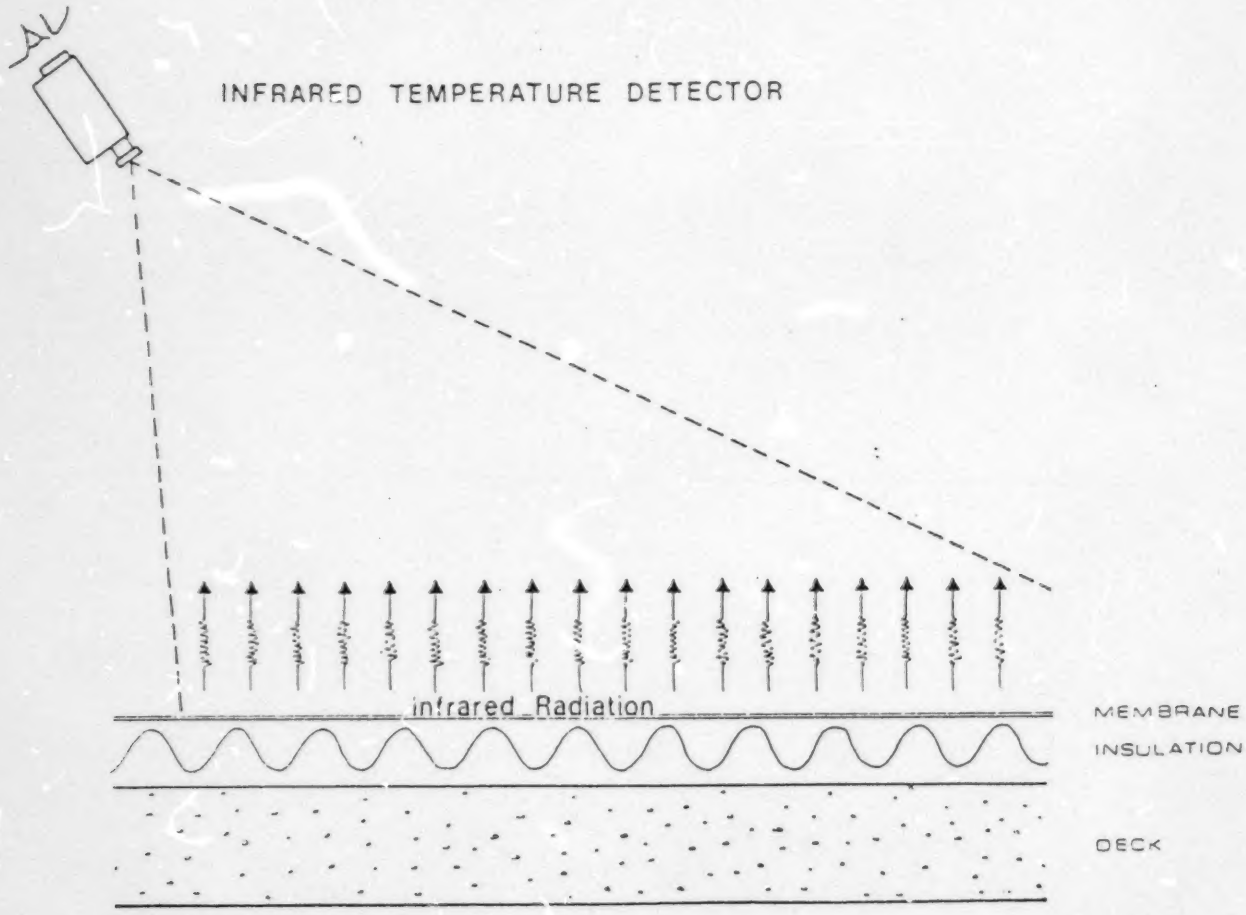
Another big tool in helping us is surveys and scans. I have here before me a layout of the three different types of scans, what they can do and what they can't do, along with some literature. I have found scans to be very helpful. When you are developing your history, you find out that the roof looks good--that the surface has no blisters, it doesn't have any splits but yet you have water penetration. What is causing it, where is it coming from? The scans and surveys are very good. Some of the ways are destructive. Let's say if we cut a roof core, usually one foot square, you weigh it, analyze it for moisture, check the construction, find out for yourself what the deck looks like. Non-destructive types are the three different ones. There is infrared, nuclear and capacitant. There are good points about all three. My feeling is that the capacitant is the best and shows you the most about your roof.

As the following diagram shows, with infrared nothing penetrates the roof. SURFACE TEMPERATURE - hot and cold spots - are noted.

Hot spots are assumed to be wet, cold dry.

An appreciable amount of moisture must be present to retain heat in the roofing system and create a hot spot.

It is impossible for infrared to be used as a predictive maintenance tool. By the time infrared shows anything the anomaly doesn't need maintenance, it needs replacing.

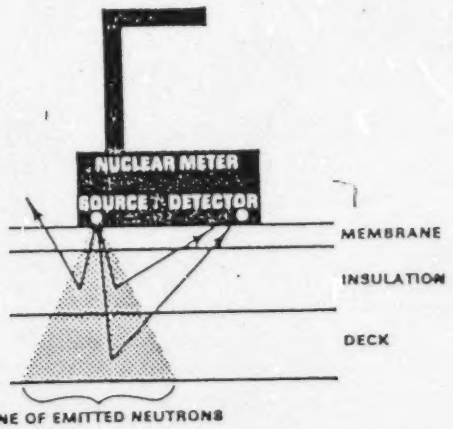


A nuclear gauge generates fast neutrons into the roof where they collide with hydrogen atoms. The fast neutrons are slowed and reflected back. A higher count indicates more HYDROGEN than a lower count.

DRAWBACK: HYDROGEN is found in water but it is also found in most roofing materials.

Thus, variation in nuclear gauge readings may indicate changes of moisture content in insulation. BUT they may also indicate variations in thickness and composition of roof deck, differences in thickness or type of insulation, variations in thickness of flood coat and/or variations in thickness of gravel.

Figure 5. The cloud of neutrons emitted by a nuclear meter.



The capacitance test measures changes in the electrical properties in the roof as they change with moisture content.

In capacitance testing an electrical field is generated throughout the roofing system. The capacitance test measures changes in the electrical properties of the roof as they change with moisture content.

Materials used in a built up roof have low and quite uniform electrical properties - roughly in the range of 1 to 4.

Water on the other hand, is very high with an electrical property of 81.

As a result, even very small quantities of moisture in a roof markedly change the electrical properties of a roof and can be detected.

Early detection means early repairs. Early repairs prevent damaged areas from growing to the point where extensive repair and replacement are required.

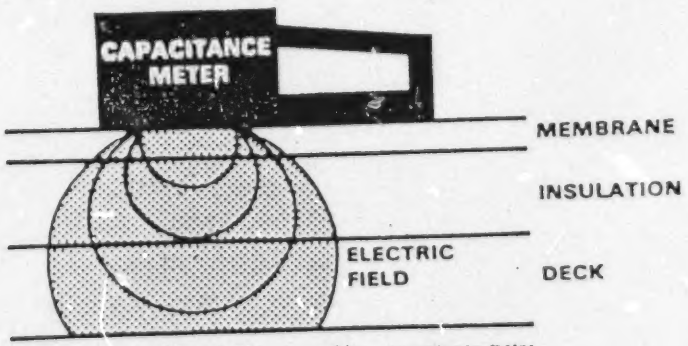


Figure 6. The electrical field generated by a capacitance meter.

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COMPARISON OF MOISTURE DETECTION METHODS FOR CONVENTIONAL BUILT-UP ROOF SYSTEMS AND SINGLE PLY SYSTEMS.

Good Value ● *Limited Value ⊖ No Value ○

CONVENTIONAL BUILT-UP ROOFS	MOISTURE DETECTION CAPABILITY		
MEMBRANE (conventional BUR)	Capacitance	Nuclear	Infrared
Membrane only, (no insulatio.)	●	○	○
Membrane only, (over insulation)*	●	○	○
INSULATION TYPE			
Fiberboard	●	●**	●**
Perlite Board	●	●**	●**
Fiberglas	●	●**	●**
Urethane/Perlite Composite	●	⊖	⊖
Urethane	●	⊖	⊖
Beadboard (EPS)	●	⊖	⊖
Cellular Glass	●	○	○
Lighweight Concrete	●	○	○
All-weather Crete	●	○	○
Urethane (w/foil backing)	○	⊖	○
SINGLE PLY MEMBRANE SYSTEMS (with commonly used insulations i.e., EPS, Urethane)			
Neoprene (ballasted)	●	⊖	○
Neoprene (unballasted)	●	⊖	⊖
PVC (ballasted)	●	⊖	○
PVC (unballasted)	●	⊖	⊖
CPE (ballasted)	●	⊖	○
CPE (unballasted)	●	⊖	⊖
CSPE (ballasted)	●	⊖	○
CSPE (unballasted)	●	⊖	⊖
PIB (ballasted)	●	⊖	○
PIB (unballasted)	●	⊖	⊖
Modified Bitumens (ballasted)	●	⊖	○
Modified Bitumens (unballasted)	●	⊖	⊖
Modified Bitumens (w/foil backing)	○	⊖	○
EPDM (ballasted)	○	⊖	○
EPDM (unballasted)	○	⊖	⊖

*Methods are limited by:

1) Inability to detect thin layers of moisture that are found in conventional built-up membranes and as thin films between the bottom surface of a single ply membrane and the top surface of the insulation.

2) Substantial amounts of insulation moisture that must be present before detection can be made.

**Method will not detect membrane moisture.

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PROBLEMS OF THE ROOF

A. Environmental Stresses

1) Sunlight - Heat and ultraviolet rays can be severely damaging over time - dry out the roof mat leaving it brittle.

2) Ozone - Again, deteriorates the roof, aging and oxidizing it.

3) Water - Accelerates deterioration of the asphalt coating by floating the volatile oils to the surface and washing away the oxidized layer, continually exposing a fresh surface to age. Ultraviolet exposure increases the percentage of water-soluble products. So again, poorly drained areas deteriorate more rapidly than the rest of the roof.
Accumulates substantial dirt and debris in time; also, airborne chemicals will collect in low spots.

4) Temperature shock - Especially in cold winter climates - the roof temperature can swing from -20^{0} at night to $100^{0}+$ if the sun is out on a clear winter day. The typical expansion and contraction of the roof is at its most severe stage under these conditions - Also, water going through continual freeze-thaw cycles works on seams and joints, especially if there are cracks or other undetected damage in the roof.

B. Physical Plant Stresses

1) Building movement - especially at control joints and re-entrant corners - These stresses will translate up to the roof which is designed generally to be a one-piece 'seamless' cover.

2) Additions to the Building - incorrect or non-existent expansion joints.

3) Deck Sag - Typical problem of drains being installed near walls or columns - Normal deflection of the decking causes the drainage to be away from drains - one square foot of water one inch deep weighs approximately five pounds so a two inch pond on a roof adds one thousand pounds per one-hundred square feet. Dangerous overload conditions are possible.

4) Wet insualtion - Same as for ponding conditions - fiberglass, for example, can hold six times its dry weight in excess moisture

SOLUTIONS TO ROOFING PROBLEMS

A. Methods

1) Resaturate - As a preventative maintenance item, if the roof is basically sound, not too blistered or split, and not too dried out, a resat can extend its lifetime six or seven years - best

Solutions to roofing problems continued

time to resat is in the eight-fifteen year old range depending upon condition of the mat. The resat is not intended to re-waterproof a leaky roof - it solely revitalizes dry, brittle felts to prevent cracking.

2) Partial tear-off - If the roof mat is in poor condition, i.e. blistering, splitting but the insulation is dry and intact, consider having the mat cut off and replaced with either a single-ply or new built-up roof. This can save considerable time and expense if you need to 'nurse' a roof along.

3) Complete tear-off - In many instances, complete removal may be necessary. It does allow you to add or upgrade insulation.

B. Roof Membranes and Constructions

1) Built-up roof

a. Gravel or smoth-surface
b. Asphalt or coal-tar pitch
c. Organic or glass felts

Current program for us is smooth surfaced asphalt roofs with glass felts. Smooth roof is aluminized after the first year to protect from the sun - glass felts used for their superior tensile strength and the fact that water will not rot the felts. Type I flat or Type II dead-level asphalts are the preferences for coating the roof because in the hot sun they 'flow' and can 'heal' themselves - Also, steep asphalt has a bad habit of alligatoring the first year the roof is on.

2) Single Plys (Most commonly used types)

a. EPDM-'Rubber' roof - Fairly good elastic properties. Can be had in very large sheets to reduce seaming. Problems are: contact adhesive for seaming; hydrocarbons (i.e. oil, etc.) will attack it. Be careful of warranties. Can be mechanically fastened or ballasted.

b. Modified bitumen reinforced sheet - Examples are Koppers 'KMM', Monroe 'Rhinohide', 'Derbigum', and 'ARC' - generally are fully adhered with a torch, which eliminates ballast. Can be installed fairly quickly with little mess. Conforms to irregular shapes of roofs. May lose plasticity in time - should be monitored closely. Warranties are available.

c. PUC - Can be installed as loose laid ballasted, mechanically attached and fully adhered. Fairly good tensile strength and good surface hardness (abrasion resistant). Seaming by solvent weld or heat gun produces more dependable seams than most single-ply. Not affected by most environmental hazards, although it may 'shrink' somewhat in time. Warranties available.

d. Metal Roof - Example: Butler standing seam roof - Advantages are: Built-in drainage as part of system, excellent

Roof Membranes and Constructions continued

durability and warranty available. Fairly expensive, however.

e. R-Values, as well as utilizing tapered insulation to correct or improve drainage. Some re-roof specifications may call for tear-off to eliminate improper or undesirable conditions before a guaranteed roof system can be installed.

f. Insulation - Considerable emphasis is being placed on heat loss through the roof, and the move to add additional insulation to the roof has been widespread. However, the greater the R-value of the insulation, the greater the temperature shock is on the roof mat or membrane.

TYPES

1. Wood Fiber - Approximate R-2.78/in. Poor roofing substrate, but is inexpensive.

2. Perlite - Approximate R-2.78/in. Very commonly used material.

3. Fiberglass - Approximate R-4.00/in. Poor impact resistance. Gets very heavy if wet. Good R/in. for cost.

4. Expanded polystyrene (EPS) - Approximate R-4.17/in. Many single-ply applications. Can be used to taper a new roof system to 'Build-in' drainage - Be careful about hot asphalt or solvents - May melt or deform board.

5. Sandwich Board - Urethane foam and perlite composite - Approximate R-4.45/in. and greater - Good substrate, impact resistance and R-value for the money.

6. Urethane Board - Approximate R-6.67 per inch. Be sure to cover with layer of perlite if used under built-up roofs to prevent outgassing of the foam (premature blistering). When checking R-values, be sure to compare aged values (ASHRAE SPECS) Also, cannot be used directly on a metal deck - Install one layer of perlite first.

7. Isocyanurate Foam - Approximate R-8.3/in. - Better flame resistant qualities than urethane foam. Also, Aged R-values are higher than urethanes.

8. Extruded Polystyrene Board - R-Value approximate 8.5/in. - Same applications and precautions as (EPS)

g. Roof Drains - In areas where a roof has sagged, installing a roof drain will help solve many problems. This is on a complete tear-off or over an existing roof with a new membrane. It is a lot cheaper than trying to build a pitch into the roof with insulation. We have installed a number of drains at an average cost of $500.00.

ROOFING SPECIFICATIONS

Some general information as everyone has their own way of writing to get the most across to the contractors:

1. Person writing should be well versed in roofing technology. Technician or consultant.

2. Know budget constraints.

3. Watch the building roof history to minimize problems.

4. Spell out the guarantee you desire.

5. Bid and performance bonds.

6. Insurance coverage.

7. Develop pre-qualifying form to save time and money.

8. Set time for Bid Tour and specification review.

   a. Contractors know who's their competition.

   b. Each one may point out something you missed in specs or an improvement needed to be incorporated in addendum.

9. Let them know there will be a preconstruction meeting on day after bid opening for them to set their schedules etc.

10. Copy of specs on job at all time.